him to raise the bid by another 5 cents and thus cut his losses. Seen from the outside, the rational thing to do is not to enter the game in the first place, or to form a coalition against the auctioneer.

Now, the interesting thing about the dollar auction is: it almost always works, because initially – it's a sliding reinforcer trap – you think, only five lousy million and we get a defence system which keeps us permanently ahead of the other side. The other side then thinks, just another lousy five million, or trillion as the case may be, and we too are ahead. And then what you get to very quickly is the situation we're in now, which is that both sides know that the eventual prize is not worth what they're spending on it, but they think that perhaps by spending just a little bit more they might recoup their past losses. So both sides are absolutely reasonable, sane people, both are adding just a little bit more to get an advantage, but the consequence is an insane situation.

How can we escape from these social traps? It's very, very hard. You either have to have an outside authority, which stops it, or you have to do a lot of education so that people don't get into the trap in the first place. What are the solutions?

(From the audience: *People should stop bidding at one dollar; it doesn't make sense to continue after that.* Consider that you have just bid me a dollar. But the other person had previously bid 95 cents. Now, if we stop the auction there, that person will lose 95 cents. By going up to $1.05, you minimize your losses, because if you won you'd have got the dollar and you'd have only lost five cents; if you don't raise the bidding you are guaranteed to lose 95 cents. One of the basic engines of competitive conflict is the attempt to minimize losses.)

What are the solutions? You can assist nations to negotiate, to understand some of those competitive situations, by giving them specific techniques, and that's where most psychologists want to put their energy, because it seems to have high pay-off. You can try generally improving relations between states so as to reduce the image of the enemy. You can try to impose an outside authority. You can ask them to stop – you can see that that's a non-starter, because it's not going to have any effect. Or, by various types of citizen action, you can either prevent one nation, or various nations, from participating.

The initial image I gave you was of a helpless child between two citadels. I think that what we have to work towards, both in terms of our science and in terms of our psychology, is an understanding that on the best available evidence even the enemy has the same nervous system that we do, and that family life is extraordinarily the same. Cultural experience does vary somewhat; however, that is now changing with the globalization of entertainment and travel. Political experience and expression differs, but that too is now changing. I would say that our shared experience is so much greater than our differing experience, that we have to concentrate on that fact and thus bring about a change in the perception of the enemy which will eventually deflate the forces which sustain the arms race.

The Militarization of Science

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1. MILITARY R&D AND SCIENCE POLICY

The choice of subject of my statement – "The Militarization of Science" – reflects a growing concern of and in the scientific community. Today, military R&D indeed occupies a commanding position in the system of world science, being its most powerful, most dynamic and most expensive sector.

Military and armament political objectives have always played a key role for science development. The history of science has always doubled as military history. Admittedly the tie-up of the two has varied considerably in the course of time. And it certainly cannot be overlooked that the importance of science and research for the conduct of wars was limited up to the Second World War.

Such as James Conant, President of Harvard University and leading science organizer of the Manhattan-Project reports that – when during the First World War he had offered the services of the American Chemical Society to the Secretary of the War Department of the USA – he received the answer it was not necessary as they already employed a chemist. At the same time just one physicist was a member of the Scientific Commission of the Department of the Navy. The chairman of the Commission, a certain Mr. Thomas Edison, suggested to President Wilson at that time to appoint also a mathematician – as he said just in case something would have to be worked out mathematically.

However, these conditions are long foregone.

Beyond any doubt, a revolutionary restructuring of the relationship between science and military had been taken place in the USA since 1940/41. Within a few years a new pattern of regulation and distribution of science resources was created in which military institutions played a dominating part. This pattern has remained stable across decades and still leaves its mark on the science system to this day. What was this pattern like?

As *politicized* science it was extensively directed to military objectives. A trend of nearly unbroken *increases* of expenditures for military research developed. *Federal* military institutions for science control evolved. *Secret* R&D dominated the science system for the first time and remained an important feature not only of the science system in the socialist countries,

but also in vital parts of the Western science systems. The military research of that time is considered as the birth hour of *Big Science*, in which project-oriented, centrally controlled and with large-scale financing privately and publicly organized research projects were tied up across all stages of research. A new instrument of science control, *contract* research emerged. These contracts were highly *concentrated* on private institutions, a *privatization* of Military R&D evolved, continuing to the present. Military Research became Big Business.

This pattern, having originated nearly half a century ago, still exists.

2. THE HISTORICAL DEVELOPMENT OF MILITARY RESEARCH

Up to the mid-sixties, the military research played the *dominating part* in the science policy of the western industrialized countries. Then a *new funding pattern* began to prevail, a diversification of the funding spectrum, in the light of which the promotion of infra-structural, ecological and welfare as well as civil-industrial oriented researches advanced to the top of research priorities. As early as in 1974/6 the transition to a *third* phase began in which at the cost of social-welfare and civil-industrial oriented research, the importance of *defence* research is constantly *rising*.

Among the 22 countries, for which reasonably reliable data over the past ten years are available and which account for the military R&D in western countries, only three nations (Australia, Belgium and Switzerland) didn't increase the level of their spending on military R&D. It is often said that there are two important exceptions of this development: the FRG and Japan. But in the FRG between 1982 and 1988, military research has become the most important single research program, swallowing up more than 20% of the federal funds for R&D at present. Our ministry of defence has become the most important state funding source for industrial research. Even Japan with its economically and technologically oriented approach has tripled its funding for military research since 1977. There is indeed a *reallocation of the resources increase* and the *resources* themselves. In nearly all Western industrial states it is the conflict carried on across more than a decade *not whether, but how fast* this change in trend in the promotion of research is to be enforced and the governmental subsidies of civil industrial research and/or for nuclear energy research is to be reduced. In the mid-eighties, in the United States over 45% of the national R&D effort is devoted to defense. In the United Kingdom, the figure is about 30%, in India 23% and in the FRG about 13-16%. The *spectacular shift of science resources* into the military sector is most obvious in the United States where the total expenditures for military research will about quadruple from $16 billion to close to $60 billion. From 50% in FY81, military R&D has grown to account for 67% of Federal R&D in FY 88.

In 1985/6 evidently this increase is beginning *to abate*. But nowhere can you see a noticeable *decrease* in the huge funds flowing into the military R&D. In the case of the FRG, the growth rate is increasing once again. And

with Japan, France, the United Kingdom and West Germany getting involved in manned spaceflight, there is a new emphasis on a dual-use technology, parts of which can easily be used for military purposes.

3. THE GLOBAL BUDGET

The topic of military research is neglected by social scientists and other scientists. No exact or reliable data on the size and dimension of global military R&D are available and the accuracy of the figures published is doubtful. There are some *estimates* and *guesses*, at best. *Secrecy* is practised here to the extreme, far more so than in civilian R&D. The Soviet Union does not publish any data on its tremendous military R&D, nor does China, another of the six major powers engaged in military R&D. The 1987 *SIPRI Yearbook* calculated that world spending on military R&D "is roughly a quarter of world spending on all R&D and in 1986 was approximately $85-100 billion a year at current prices." Moreover: "Of the world's 4 million R&D scientists and engineers, probably over three-quarters of a million are engaged in military R&D. If support people are included, there are probably at least one and a half million people in the world working in military R&D." With the inclusion of the known increases of private industrial funds devoted to military research and those spent through other budgets one must come to the conclusion that in *1988* the *world expenditure for Military R&D* will reach the level of *$140-160 billion*, more than *30%* of the global research expenditures will be channeled into military research – this is equal to more than 1% of the world's gross national product. Over *one million scientists and engineers* will find work in that field.

4. WHAT ARE THE CONSEQUENCES?

The question how the military use of more than a third of the world's R&D activities influences science *in toto* is very seldom posed. What are the consequences?

4.1. North-South Gap

To be sure, military R&D is the centre of the *technological arms race*. But there are other less visible effects of military R&D. Around 95% of R&D is concentrated in the North. Dominated by military R&D, total global R&D evinces little interest in developing problems of the *Third World* and at the same time, larger Third World countries such as India, Brazil, South Korea, Egypt or Argentina devote a considerable part of their R&D funds to military purposes. It is a driving force for rearmament in the Third World, reinforces the arms acquisition process in the South and transfers industrialization patterns to the south, which are marked by their high level of technology and capital-intensity, being rarely compatible with balanced development. Thus, military R&D acts to sustain under-development in the Third World, *reinforcing the North-South gap*.

4.2. Changing Funding Patterns

The situation in the field of *science policy* seems to be quite obvious. Since the mid-seventies, there is a startling *neglect of social, civil and ecologically oriented research.*

In the U.S., between FY 1981 and FY 1988, federal military R&D has increased 71% in constant dollars (1982); funding for civilian applied R&D in such areas as energy, oceanography and the social sciences has declined 26% over this period. In the mid-eighties, the federal expenditures for military R&D in the U.S. exceeded the funds for ecological and welfare state-oriented R&D approximately more than 50 times. The civil energy research has been reduced so strongly since 1980 that the Department of Energy became a second ministry for military R&D by doubling the expenses for nuclear military energy research. In the FRG, the government spends precisely 10 times more on military research this year than on environmental research or on research on renewable energy, 20 times more than on research for the humanization of work and 1000 times more than on peace research.

4.3. Neglect of Basic Research

The rapid militarization of science quite obviously has led to a relative *neglect of basic research* with *simultaneous development of military basic research.* In the United States, the percentage for military basic research of the research budget of the DoD ranges approximately one third to one fourth lower than the percentage of the basic research of the entire national R&D budget (3.1% vs. 12.6% in 1984). The shift of the research funding to the military sector therefore equals an adverse affect on basic research. The ministries of defence in the FRG and England even claim to not promote any projects of basic research at all. Yet on the other hand under the assumption, that with the shortening of the military innovation cycle at least a number of individual fields of basic research will become directly relevant for the military, the military institutions have continuously intensified their engagement. Basic research is becoming militarily relevant.

4.4. Secrecy in Science

And finally, for more than a decade now, the issue of "*secrecy in science*" is on the political agenda. Approximately 20% of the R&D budget of the DoD is secret, is a black budget, an amount in excess of the science budget of many European nations. This practice of black-budgeting increased during the past decade, not only in the United States but also in the FRG and other countries. The correlative extension of a somewhat old-fashioned classification practice was paralleled by another very dangerous development, whose political point of origin was a report of the "Defense Science Board" of 1976 (Bucy-Report). Here the thesis was developed that military and civil technologies increasingly *converge* and a rapidly growing sector of "*sensitive*", "militarily relevant" or "critical", "dual-purpose" technology came into being.

This change in the development of modern technology was to have to two consequences for science policy. On the one hand, the military technology had a high *spin-off* for civil economy. That thesis of war being the father of all things is nothing new, as we know. On the other hand, and that is the far more consequential, politically offensive aspect of the argumentation, according to this view research and technology, up to now utilized only civilly, will be effective militarily too and hence become *militarily relevant* – hence ought to be under the control of military institutions. As a logical consequence, a science policy originated in the beginning of our decade which systematically tries to subjugate explicitly *non-classified, civil* research to governmental control and limits its circulation. The actions taken or attempted by the government include: barring foreigners from attendance at unclassified conferences; pressuring authors to withdraw unclassified papers from open meetings; pressuring researchers in certain fields to submit their unclassified research papers to government agencies for prepublication review; including clauses in unclassified university research contacts that prohibit participation by foreigners; barring foreigners from unclassified research and computing facilities (Robert L. Park). Now the government seeks to control "commercially valuable" information. We must put it in this way: *there is a revitalization of censorship as instrument of military science policy.*

4.5. The Economic Impact

To be sure, there is a debate on the *economic impact* of military R&D. It is difficult to evaluate the direct effects of research on economic growth and industrial productivity, as it is with R&D in general. But there are strong arguments for negative effects. Military goods and services neither contribute to the present standard of living, as do consumer goods, nor to the economy's capacity to produce and contribute to the future living standard, as do producer goods. As Seymour Melman has said: "*You cannot live in, wear, or ride an international missile*". They neither clothe, house, feed, entertain, nor are they tools for producing goods and services that do (Dumas). Military R&D contributes to the production of so-called *non-reproductive* goods.

One special trait of military technology is of particular importance in this regard: the pursuit of the highest and most sophisticated technology makes it very often not suitable for civilian production. This has to do with functional requirements and with the political process of building-up successful military-technological programmes.

5. WHAT IS MILITARY RESEARCH?

From a sociological point of view, military research differentiates chiefly by its *function* – to enable the production of military goods – and by the fact that the *evaluation* of the research achievements and results is done neither

by the *scientific community* nor by the *market*. The place of scientific and economic evaluation, *i.e.* performance criteria is taken by *political* criteria. It is no longer scientific *truth* or economic *profit* which governs and controls the research projects but *political* needs. Since that research is financed by public budgets, the question of *cost effectiveness* is of minor importance – and since the state is the singular contractor, demanding party and user all in one, there will be no independent judgment by those political elites of the technologies, their effectiveness and consequences for those not part of those elite groups. The effect is that huge scientific and technological projects can be initiated without including the public.

Military systems are far more elaborate than their civil counterparts. They often embody degrees of durability and performance far greater than are normally required for civil products, and also embody exceptional features, such as radiation hardening or invisibility (remember the new and incredible expensive "Stealth"-technology). *Military R&D answers questions no one posed in the civil society and solves problems which aren't any.* There is no reasonable demand on the side of the civil society for an invisible technology.

Military-technical large-scale systems are often examples of a "*triumphalistic technology*". This does *not* mean that military technology is *out of control*. There are choices to be made between different technical pathways and there is a range of political and institutional factors shaping these choices. These factors also shape the options that are available and can enter into the definition of what is possible. On the other hand, technology is not simply a dependent variable. It can sometimes be important as an enabling capability or a limiting constraint, providing – not determining – the course actually followed. "Technology" and "Politics" are so hard to distinguish, *because any successful programme obviously must "work" both technically and politically*. In their historical case study of the evolution of Fleet Ballistic Missile guidance and navigation technologies by tracing the origins and development of the Trident system, Donald MacKenzie and Graham Spinardi developed the concept of the "*black-boxing*" of programmes: a black-boxed programme creates a boundary between technology and politics and produces a distinction between both. What is inside the black box is technical, what is outside is political. The formal political system is presented with simple decisions, between buying the package, the black box, or rejecting it. They are not troubled by "technical detail". And it is interesting, that since the mid-70s, the interventionism and micromanagement of the formal political system has grown. The MX is an example. One response from the military side has been to extend the category of black programmes.

6. CONCLUSION

What does it mean for the scientist if it has become typical for civil and military research to converge to such an extent that they become almost

indistinguishable? If every technology can be doubly deployed – militarily as well as governmentally? If – and this is the consequence – every civil research also has military consequences, then a concerned scientist does not have a chance to prevent military misuse of his research results? A situation with no way out is urged upon him: either he discontinues being a scientist or he accepts his co-operation in the continued perfectioning of a global military system.

I think we can make distinctions. *Military technology assessment* is difficult, but it is *possible* and it could form the intellectual basis for the necessary *change of direction of science policy*. Science and technology should serve peace and not war. It is certain, that a good case can be made that there are aspects of military technology which can improve crisis-stability and stabilize the arms race. It follows that research in these beneficial aspects *should be encouraged. General or selective research bans are not desirable or possible*, but test bans for example of strategic weapons are possible, because they can usually be verified. Thus, a constraint on the last stage of the research race is possible. *Scientists have one alternative.* It might be that the scientists themselves and the interested public take up the issue of military R&D, hence giving it the priority it so greatly deserves. And they can stop doing research for the military and work instead for civil research which is of value to science and society. There are numerous tasks: tracking down the military *history* and *functions* of science; creation of a new *value system* of science, which discriminates military research on moral grounds; support of the *peace movement*; finally: *science disarmament and build-up of a lively science for peace.*